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ABSTRACT

This tennis stroke analysis, based on the application of biomechanic principles, is designed to help those who play tennis only once or twice a week. It is noted that, because the tennis player has a limited power potential, the only way to increase his racket head speed is to rotate his body. The mechanics of tennis are discussed by dividing it into: (1) ground strokes; (2) footwork; and (3) forehand and backhand. The section about ground strokes talks about how to stand, how to hold the racket arm, and how to distribute body weight; the stroke is subdivided into the step, the rotation, and the swing. The section on footwork discusses (with illustrations) the position of feet on the court, four different types of step selection, the follow through, and the defensive position. The section on forehand and backhand strokes describes both processes, and the proper grip for each. Throughout the paper, specific application of biomechanic principles is made to help the tennis player who plays occasionally to improve his or her game. (JM)

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Qualitative Biomechanics and the Tennis Ground Strokes

by

Joseph Errington

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SOME BIOMECHANICS

Any time that speed of an object is being changed, be it a car, bicycle, bat or tennis racket, a force must be applied for a period of time. It takes you time to get your car moving at 100 miles an hour. It takes time to stop a car moving at 100 miles an hour. This is true, no matter how big the engine is, no matter how good your brakes are.

Exactly the same considerations must be made when you are concerned with putting a tennis racket into motion, the big difference being that here is a limit to the amount of power the human body can generate. Human power is obviously dependent upon the number of muscles which are able to contribute, and the sequence in which these muscles add their power. Thus, with a limited power potential, the only way to increase racket head speed is the increase of the time over which the power which can be generated is in application.

This increase in both force and time of application (impulse) is accomplished by the use of rotation in human movement. By starting with the side to the target, (as in the overhand throw), one gains in several different ways: 1) the big muscles of the back leg (the extensors) and the abdominal rotators drive the body into rotation so the performer ends up facing the target. This provides the biggest reasonable force; 2) The fact that the performer is sideways also provides the longest feasible time for these big powerful muscles to operate (through 90° of rotation); 3) Extra momentum is gained by the initial step which starts the racket moving before anything else happens.

This is the heart and soul of the following tennis stroke analysis. In other words, all other techniques aside, this analysis is based upon the application of biomechanic principles, as noted above. This is deliberately introduced, as it is contended that sound application of these principles will help those of us who play tennis for recreation and play once or twice a week. The hope is that we can play with some consistency and some success. Biomechanic considerations can help with this considerably.

THE GROUND STROKES

The basic stroke as recommended here is essentially the same for both the forehand and the backhand. Therefore the initial part of the analysis relates to those elements which are common to both strokes. Special changes in one or the other are analyzed subsequently.

THE BASIC MOTION

A. Initial Position

1. Sidewayness or Counterrotation

The initial position for both strokes places the side to the net, or the body at at right angles to the net. For the right handed player, the forehand has the left side nearest the net, the backhand has the right side nearest the net. Going back to the aforementioned biomechanics, the sideways position makes it possible to apply force for a longer period of time. Further it makes it possible to get more muscles into the act. Both the back leg extensors (power muscle) and the abdominal rotators are included, which any other position will preclude, or introduce variables which will make control difficult.

2. The Arm

The racket arm is relatively straight, and held so that it is well away from the body and on the opposite side of the body from the net. The racket is held firmly so that it points both upwards and backwards. This position assures the best hold on the racket. By way of indicating how this works, hold onto your racket very firmly, but with a bent arm. Have someone grab the racket and shake and twist it. Feel how readily it moves. Now straighten the arm and try the same thing. You will find that the latter position makes for a much more firm hold on your racket. The reason for this occurance is that by keeping the arm straight the performer will use a muscle called brachio-radialis to help prevent the forearm from pronating or supinating. When the arm is bent this muscle can't do this.

Further, the straight arm also makes for a longer lever arm. Thus, what power is developed in the rotation is amplified by the longer lever arm (just as a bicycle sprocket increases the speed of the wheel by adjusting the relative length of the power lever arm.

A similar reasoning applies to the manner of holding the wrist. The strongest wrist position is with the forefinger pointing in line with the bones of the forearm. Any other position places the muscles that operate the wrist at a disadvantage and therefore makes racket control at impact more problematic. This is particularly true of ulnar or radial deviation positions. Thus if the hand is kept in its normal position, the racket is going to be at angle to the length of the arm, (above the wrist for most strokes).

3. The Body Weight

The weight is somewhat on the back foot, so that you can easily take a step toward the net. It is necessary to keep the weight on the back foot as it is impossible to take a step without first freeing, or taking the weight off the foot onto which you plan to step. Try it and see.

4. Readiness Position Modified

At all times there is flexion of the ankle, knee and hip. This is the readiness position adapted to the stroke. The flexion of the ankle, knee and hip does two or three different things that help. First it makes a good quick effective movement more possible, because you have eliminated any unneeded preliminary movements. You must go through this position if you do plan to move, so why not start that way. Secondly, this flexion will help keep the head relatively level throughout the stroke, making it easier to hit the ball. If the head is changing levels, the brain has more to adjust for, and therefore may be more likely to make a mistake. So why not just eliminate the problem (variable).

Further, the very fact that the knees are bent permits better extension of the very power muscles we want to use to make the rotation.

B. The Stroke

1. The Step

The first movement of the stroke, after the preparatory moves, is a short step toward the net. Optimally this step is such that a line between the toes of both feet will be at right angles to the net. This step plays the role of getting the racket moving toward the ball before any other motion takes place, thus breaking inertia. Or said the other way, it gives the racket momentum so that whatever effort follows will be added on top of the step.

2. The Rotation

This step is followed directly by a distinct rotation of the body toward the net. This comes from two major efforts; first, the drive of the back leg against the front leg so that the body is turned by this effort, second and simultaneously occuring, is the rotation of the body created by the muscles of the abdomen which turn the body. This rotation precedes the arm action, and in a sense pulls the arm around toward the ball without any motion of the arm itself. This effort then puts two very powerful muscle groups into the act, which most often are not used. Indeed most of us use only the little muscles of the chest when we hit, which in terms of racket head speed and control is less than good. As was indicated before, not only does this rotation place more muscles in the act, but it means that they are able to operate for a longer period of time, which in turn means greater racket speed. And all of this before you have even moved the arm!

3. The Swing

Right after the rotation the action of the arm takes place. This is the accuracy and control element of the swing. This is a swinging motion, level and straight into the plane of the ball traveling toward you. The arm is best held somewhat down and away from the body, with the racket head above the wrist and firmly held. If you have generated the racket head speed with the body rotation then you can afford to use the arm muscles for control. Too many of us must use these accuracy muscles for generation of speed which obviously means that they are unable to provide the nice control which we desire. The wrist is held firm but can be slightly flexed or extended to give the forehand court or backhand court directionality as desired. Otherwise the wrist stays firm. See The Arm.

FOOTWORK

Probably the most neglected aspect of the tennis skills relates to effective footwork.

A. Sidewayness: A Choice

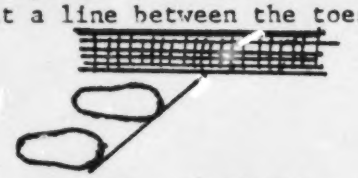
As has been indicated above, the optimum stroke, in terms of both power and accuracy, will result from the sidewayness of the body before the actual motion takes place. Any deviation from this position will detract somewhat, and the greater the deviation the greater the detraction. So that if the player steps across his body so that the line between the toes goes clearly toward the sideline vs. the net, then there is a limit placed on the amount of rotation possible, which limits power, and detracts from the optimum results desired.

In other words, it is quite important that the feet be arranged so that the toes are lined up at right angles to the net (at least close to this).

B. Lined Up

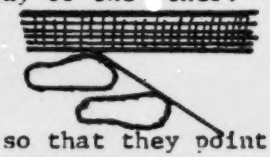
"Lined Up" is the term which shall be used hereafter to mean body sideways to the net, the arm held away from the net, and a line between the toes of both feet will be at right angles to the net.

This is the optimal position for effective mechanics. If the front foot is placed so that a line between the toes goes toward the net post in front of you,



there will be the necessity of limiting the rotation. The hips just won't move that far, so the rotation has to stop sooner.

Thus a major source of power is lost. Racket velocity must, therefore, be developed by the muscles we have to use for control, the arm and chest muscles. These muscles can't give control and velocity at the same time. Thus the stroke has to suffer, one way or the other.



If the toes line-up so that they point toward the net post behind you, then some of the rotation possible is wasted. You will strike the ball before you reach the end of your rotation and thus the force is not in operation as long and racket speed will be less.

C. Keeping Away

In addition it is important that the feet be placed so that the ball will meet the racket with a straight arm which has the hand somewhat out from the body. Said another way, there is a need to stay away from the ball. The length of the racket and a little bit, is the distance between the ball and the body of the hitter. It should be pointed out, that there is quite a bit of leeway for the less than perfect judgement of the steps. If one steps so that the ball is just out of normal reach, there is very little negative effect on the stroke if the arm is extended somewhat out from the body to hit the ball. There is a limit to this, but for most of us there is at least 1½ to 2 feet of extra reach away from the body. However, should you overstep and get too close to the ball, you are in trouble. The only way to hit the ball is to sort of pull the body out of the way and hit the ball with a bent arm, a movement certainly less than effective, as we have seen.

D. Step Selection

Step selection is a matter of choice, a cerebral judgement which leads to effective movement. You can get some fair results by stepping across the body, but if the best results are needed then something else must be done, thus the judgement process then is very important.

It should be pointed out, that there is a lot of room for adjustment to the ball, by the length of the strides which are used as you are making your effective footwork selection. If the ball is not too far away, shorter strides will do. If it is toward the end of your reach, longer strides will increase your range.

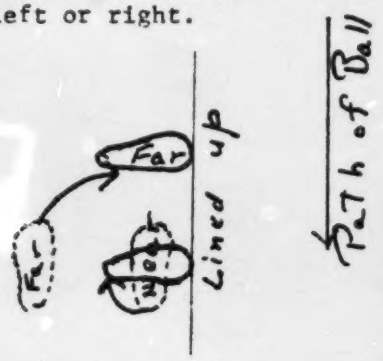
Always try to understride and over reach.

Overstride leads to under reach which leads to wet noodle shots (bent arm strokes) which are much less than effective.

1. The One Stepper

This is the basic stroke placed directly after a pivot on the foot nearest the ball. In other words, the foot "farthest" from the ball is brought across the body to a lined up position with its mate (other foot).

You will note my use of the term "farthest". This is deliberate. The same action applies to either a left hander or a right hander to forehand or backhand. Thus throughout these notes there are references to the farthest foot/arm and nearest foot/arm, not left or right.

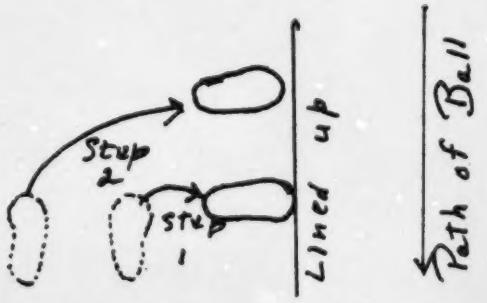


2. The Two Stepper

When the ball is coming so that it would pass clearly outside the reach of a one stepper, but not much more than that, we use the two stepper. And just as implied, all we do is put a step in front of what was just described as the one stepper.

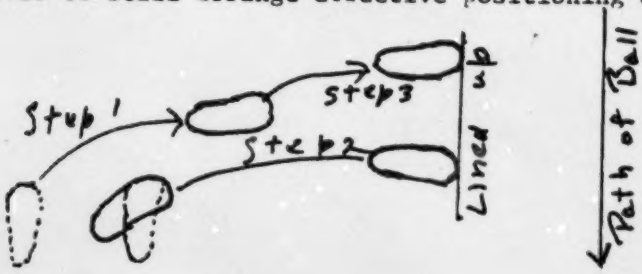
In order to make the last step that which is toward the net as in the one stepper, it must be carefully arranged so that we make the first step with the near foot (the foot nearest the ball flight). The second step then is to line up the toes on the net. Now the rotation is possible, and the effective shot can result.

Many players will move as a one stepper (above) and step across the body to reach the ball. This means that the feet are not in line, and this means limited power/control.



3. The three Stepper

It should be evident by now that the three stepper is the footwork used to get effective rotation when the ball is still farther from you. The initial step now is with the foot farthest from the ball, the second with the near foot, the last step being toward the net to line up the feet and be in good position for the rotation, as has been the case throughout. As was pointed out earlier, the length of the stride in going toward the path of the ball can adjust the distance you cover to still arrange effective positioning over quite a range.

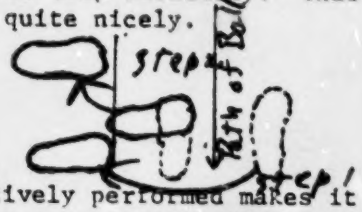


4. The Navel Footwork (Navel, because if you don't move that's where you will get it)

This ball, right at you, causes special problems. Before you were moving to get to the ball, here we must move to get away from the ball. As most of us prefer, and have stronger forehands, we can, and usually do, choose to move to set up the forehand. The movement is really a way of getting away from the ball, and still being able to get the effective lined up position of the feet.

The first step is with the nearest foot, and it is a good big step away from the line of the ball. This is toward the sideline which will be at your back as you are making the stroke. The completion of the motion is then to line up the toes so that they are at right angles to the net. This last step is again away from the ball line. Many players forget this last part and thus force themselves into making weak bent arm wet noodle strokes which are not effective and which the opponent delights to hit back, making you look less than effective. Sound footwork prevents this.

It should be noted that you may have to use a variation of this same motion to arrange the feet effectively for the ball coming close to you but not that close. The adjustment is in the length of the first step basically. This permits you to select the optimum distance from the ball quite nicely.



In summary then, the footwork, effectively performed makes it possible to establish the effective mechanical procedures to assure effective speed and accuracy of the hit. The role of footwork, after the strokes have been mastered, will have more to do with the success of your tennis than any other single aspect of the game.

5. The Follow Through

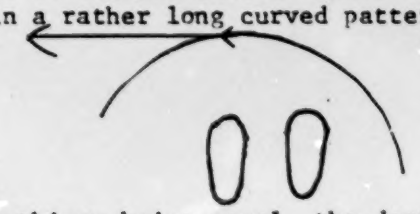
The follow through is a continuous motion in the general direction that the hit has been going, beginning to go upwards when the racket and the straight arm is pointing at right angles to the net. This follow through is essential to the steady speed of the racket head. Should you want to stop the racket shortly after

you have hit the ball, you must start to stop the racket before you hit the ball and therefore change the speed of the racket head as it hits the ball. In like manner, if the followthrough changes direction as the hit is made, the ball will be hit in the wrong direction as the new directionality was started before the ball was hit.

6. Accuracy

The advantage to the use of the rotation for the major source of power of the hit is that it leaves the smaller control muscles to do the controlling. Very often, amateur players use these small control muscles of the hand and arm for power, and thus they lose their ability to provide the control which is essential in good tennis.

It should be evident that if there is rotation of the body, the racket head must travel in a rather long curved pattern around the body, indeed around the front foot.



Thus all things being equal, the desired path of the ball will have to relate to this arc. Which is exactly what produces accuracy.

Common knowledge should tell the reader that the face of the racket must be at right angles to the desired path of the ball if the ball is to take that path. Thus it is necessary to find the point in that arc when the face of the racket is at right angles to the path desired. Or when the tangent to the arc coincides with the target path of the ball. So that the key to accuracy is timing - when is the tangent going at the target.

However, if we have generated good speed with our rotation (leg and abdominal rotators), then we don't have to use the wrist muscles for speed, so we can change the angle of the racket just a little bit with wrist flexion and change the direction completely. If we are using wet noodle techniques (bent arm) this is almost impossible to accomplish. So a good straight firm arm is the basis around which accuracy is built.

Most often we want the ball to travel relatively flat or parallel to the ground. This is the reason that we want to swing the racket horizontally, as much as possible. This is true even for the very low ball. In order to make this horizontal stroke when the ball is low all we do is bend both knees as we are "last" stepping (lined up) and keep the rest of the motion much the same. The upwardsness of the ball comes from slight outward rotation of the shoulder which will trun the racket face upwards slightly, in the forehand and greater hyperextension of the wrist in the backhand stroke.

7. The Defensive Position

Returning to the readiness position is absolutely essential once the ball has been hit. You must be facing the net, with good flexion of the ankle, knee and hip so that quick movement is possible. And of course you have returned to the initial position on the court.

Forehand vs. Backhand, Some Particulars

As has been indicated, the essential mechanics of the forehand and the backhand strokes are the same. The differences come in recognition that the backhand strokes (those strokes made on the side of the body opposite to the hand holding the racket) must involve the less powerful muscles on the back of the body. Most human movements are done with the muscles of the front of the body, particularly where the arms and hands are concerned. Therefore, these muscles are stronger and more effective. When we have to hit from the other side, unless we change hands and become ambidexterous, then the backhand must use the weaker, and less effective muscles of the back of the chest and arm.

A. The Grip

Forehand Grip

The forehand grip recommended here takes advantage of the strongest and most common actior of the wrist, that being flexion. In order to get this advantage the face of the racket must be in the same plane as the palm of the hand. This is obtained much as if you were shaking hands with the racket, when the face of the racket is horizontal. The racket handle should cross the palm of the hand diagonally, with the butt of the racket by the heel of the hand, the rest of the racket passing between the thumb and the forefinger. This gives the best position of the hand to resist the action of the ball and not be moved by the ball as you hit it.

The Grip (Continued)

Backhand

There is a need to adjust the grip for the backhand because of the weaker muscles of the wrist extension movement. In order to get the strongest position for the backhand stroke, the wrist is hyperextended. This position places the leverage of the wrist so that it is in its least weak position and the real resistance to ball momentum is applied by the outward rotators in the shoulder. If the hand is kept in its normal extended position, the longer lever arm of the wrist makes the resistance the extensor muscles can apply considerably less, and so there is a tendency for the weak wrist and the resultant ineffective hit.

Thus the racket, if we kept it the same as the forehand, and still hyperextend the face would be facing the wrong way - very much upward. So the backhand grip simply adjusts for this by turning the racket about forty five degrees so the top of the racket turns toward the fingers. This makes the face of the racket parallel to the net.

A most popular approach to the backhand nowadays is the two hand grip, which is probably the most effective. In this case the same backhand grip adjustment is made, but the free hand is placed on the handle above the other hand. This offers still more resistance to the ball and thus makes for better shot potential.